Research Report 1452

Use of the Multipurpose Arcade Combat Simulator To Sustain Rifle Marksmanship in the Reserve Component

Joseph D. Hagman
Army Research Institute

Heber G. Moore, Mark E. Eisley, and Myron P. Viner
Allen Corporation of America

Boise Scientific Coordination Office
Training Research Laboratory

U. S. Army

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This research sought to determine whether MACS training can effectively sustain rifle marksmanship skill, and, if so, identify the amount and schedule of training that produce maximum payoff within the Reserve Component setting. Questionnaire responses revealed that 93% of the soldiers in the experimental groups thought that MACS training would improve their marksmanship performance, 98% enjoyed the training, and 96% would practice with MACS if it were available at their local armory. Although findings suggest that MACS training was

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ineffective in promoting the sustainment of rifle marksmanship skills, this conclusion must remain only tentative because in most cases the null hypothesis was not rejected. Thus, factors other than the ineffectiveness of the training device must be considered as possible contributors to the lack of statistically significant results. Such factors include inherent weapon variability, small sample sizes, insufficient MACS training, a too-lengthy, no-practice interval between the last MACS practice session and postrecord firing, and the need for an instructor during MACS practice sessions to ensure effective feedback. Future research is suggested to account for the potential contributions of these factors.

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Joseph D. Hagman
Army Research Institute

Heber G. Moore, Mark E. Eisley, and Myron P. Viner
Allen Corporation of America

Boise Scientific Coordination Office
Ruth H. Phelps, Chief

Training Research Laboratory
Jack H. Hiller, Director

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

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FOREWORD

This report examines whether training with the Multipurpose Arcade Combat Simulator (MACS) can effectively sustain rifle marksmanship skills of Army National Guard (ARNG) soldiers, and if so, how to manage and integrate MACS during Inactive Duty Training (IDT) to maximize payoff. Results suggest that training with MACS, in its current hardware/software configuration, may not help sustain rifle marksmanship skills. Possible reasons for this finding are discussed.

This research was conducted by the Training Technology Field Activity--Gowen Field (TTFA--GF), whose mission is to improve the effectiveness and efficiency of Reserve Component training through the testing and application of training technology. The research task supporting this mission is entitled "Application of Technology to Meet Reserve Component Training Needs" and is organized under the "Maintain the Force" program area. The National Guard Bureau (NGB) and the Idaho Army National Guard (IDARNG) sponsored this project bnder a Memorandum of Understanding, signed 12 June 1985, establishing the TTFA--GF. Project results have been presented to Chief, Training Support Branch, NGB, and the Assistant Adjutant General of Idaho.

EDGAR M. JOHNSON
Technical Director

USE OF THE MULTIPURPOSE ARCADE COMBAT SIMULATOR (MACS) TO SUSTAIN RIFLE MARKSMANSHIP IN THE RESERVE COMPONENT

EXECUTIVE SUMMARY

Requirement:

Determine whether MACS training can effectively sustain rifle marksmanship skill, and if so, identify the amount and schedule of training that produce maximum payoff within the Reserve Component (RC) setting.

Procedure:

Individual Army National Guard (ARNG) soldiers of different marksmanship ability were assigned randomly to one of five groups (one control and four experimental) on the basis of live prerecord fire performance. Separate groups then received different amounts and schedules of MACS training followed by live postrecord fire. The Control Group received no MACS training between pre- and postrecord firing. The Familiarization Group received one session of MACS training a month before postrecord firing. This MACS session consisted of practice record fire, point of aim, diagnostics, and practice record fire again, in that order. The Massed Group received three successive sessions of MACS training with a 5-minute break between sessions. The Spaced-short Group received three sessions of MACS training with a 2-hour break between sessions while the Spaced-long Group also received three MACS training sessions, but spaced at 1-month intervals. The interval between pre- and postrecord firing was 4 months for all groups, whereas the interval between the last MACS session and postrecord firing was 1 month for each of the experimental groups. After MACS training, soldiers completed a written questionnaire designed to reveal their opinions about MACS effectiveness, solicit comments about how MACS could be improved, and determine whether or not they would use MACS if it were readily available.

Findings:

Contrary to expectations, performance of the control group did not decrease over the 4-month, no-practice interval between pre- and postrecord firing. In addition, none of the experimental groups that received MACS training performed better than the control group on live-fire measures of shooting accuracy or variability. Only soldiers with low incoming marksmanship ability profited from any sort of shooting experience, with MACS or with real weapons. Questionnaire responses revealed that 93% of the soldiers in the experimental groups thought that MACS training would improve their marksmanship performance, 98% enjoyed the training, and 96% would practice with MACS if it were available at their local armory.

Utilization of Findings:

Although findings suggest that MACS training was ineffective in promoting the sustainment of rifle marksmanship skills, this conclusion must remain only tentative because in most cases the null hypothesis was not rejected. Thus, factors other than the ineffectiveness of the training device must be considered as possible contributors to the lack of statistically significant results. Such factors include inherent weapon variability, small sample sizes, insufficient MACS training, a too-lengthy, no-practice interval between the last MACS practice session and postrecord firing, and the need for an instructor during MACS practice sessions to ensure effective feedback. Future research is suggested to account for the potential contributions of these factors.

USE OF THE MULTIPURPOSE ARCADE COMBAT SIMULATOR TO SUSTAIN RIFLE MARKSMANSHIP IN THE RESERVE COMPONENT

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BACKGROUND

To bolster readiness in the Reserve Component (RC), the Army is considering a major investment in training devices and simulators for individual and collective training. The need for devices and simulators is at least as great in the RC as it is in the Active Component (AC). Soldiers in the Army National Guard (ARNG), for example, must meet the same performance standards as their AC counterparts, but have roughly one tenth the training time available to do so. Training resources, such as ammunition, fuel, equipment, and range or maneuver areas are also more limited in the ARNG. These difficulties are compounded by the geographical separation of units. This separation makes it difficult to provide uniform, quality instruction that meets individual and unit needs because of the management and logistical problems encountered when trying to allocate, share, and schedule constrained resources across dispersed locations.

It is anticipated that simulators and training devices will help alleviate these difficulties. One device being considered for fielding is the Multipurpose Arcade Combat Simulator (MACS) developed by the Army Research Institute's (ARI) Fort Benning Field Unit. The MACS is a low-cost, part-task, marksmanship training device that uses off-the-shelf components to provide the trainee or shooter with feedback about location of bullet strike and shooting technique.

Effective and efficient use of devices such as MACS will be key factors in determining ARNG readiness and ensuring maximum return from training investment. Before a decision is made to field MACS in large quantities, however, it is necessary to know whether it enhances the skills it purports to train and how to integrate and manage use of MACS within current ARNG training programs. Without knowledge of MACS' full range of capabilities and the specific skills to which it is best applied, ARNG training managers and trainers cannot be expected to develop and conduct high-quality training programs with MACS once it is fielded.

Some research has already been done to evaluate MACS effectiveness. Results of initial work showed no improvement in marksmanship skill as a function of practicing with MACS (Perkins, Selby, Broom, & Osborne, 1985). Prompted by this finding, MACS software was improved (Schroeder, 1985b). As a result, subsequent findings have been more encouraging. Performance on MACS, for example, has been found to correlate with performance on the more expensive Moving Target Rifle Marksmanship Trainer (MTRMT), indicating that the two devices measure common factors in trainee or shooter performance (Schroeder, 1985a). Performance on the MTRMT also has been shown to correlate with live-fire performance (Schendel, Heller, Finley, & Hawley, 1983), and thus, correlation between MACS and live-fire performance is possible. Finally, results of an evaluation conducted at Fort Jackson, SC, support MACS effectiveness. By using MACS both as a diagnostic aid and a follow-up training tool, the marksmanship qualification rate for female trainees was increased by 15% (U.S. Army Memorandum, 1985).

Although promising, past research has focused solely on the initial training of marksmanship with basic trainees. The problem within the ARNG, however, is one of sustainment, because ARNG soldiers have already acquired basic rifle marksmanship skills. The purpose of the present research, therefore, was to determine if MACS training can effectively sustain rifle marksmanship over prolonged periods of no practice, and if so, identify the amount and schedule of MACS training required to produce maximum sustainment payoff within the ARNG setting.

In general, marksmanship performance of five groups was compared. All groups shot record fire on an indoor range both before and after the experiment. Four of the groups received different amounts of MACS training over either massed or spaced schedules between record fires while the fifth group received no intervening MACS training. The specific questions of interest were:

1. Does MACS training sustain rifle marksmanship?

2. How much MACS training is necessary for effective sustainment?

3. Which training schedule is better (massed or spaced)?

4. Which spaced interval is better (long or short)?

5. Does MACS performance improve, and if so, is improvement on MACS associated with improvement in live-fire performance?

6. Which MACS performance measures are predictive of live-fire performance?

7. Would soldiers use MACS if it were available?

METHOD

Subjects

One hundred and one (86 male and 15 female) Idaho ARNG soldiers representing forty-one different military occupational specialties (MOSs) participated in the experiment. These soldiers averaged 28.1 years of age, had 2.1 years of AC service and 5.4 years of RC service and held a median rank of E4.

Apparatus

The MACS hardware configuration consisted of a light pen attached to the barrel of a nonrestorable M16A1 rifle, an off-the-shelf microcomputer and a color video monitor (see Figure 1). At the time a target was placed on the screen by the computer, it began to read where the light pen was aimed by sensing each time the electron beam of the monitor passed the light pen point of focus. Based on where the light pen was aimed on the screen when the rifle trigger was pulled, the computer determined the X and Y coordinates (screen pixel location) which corresponded to shot location.

Hits, miss distances, and other marksmanship performance data were derived on the basis of these coordinates.

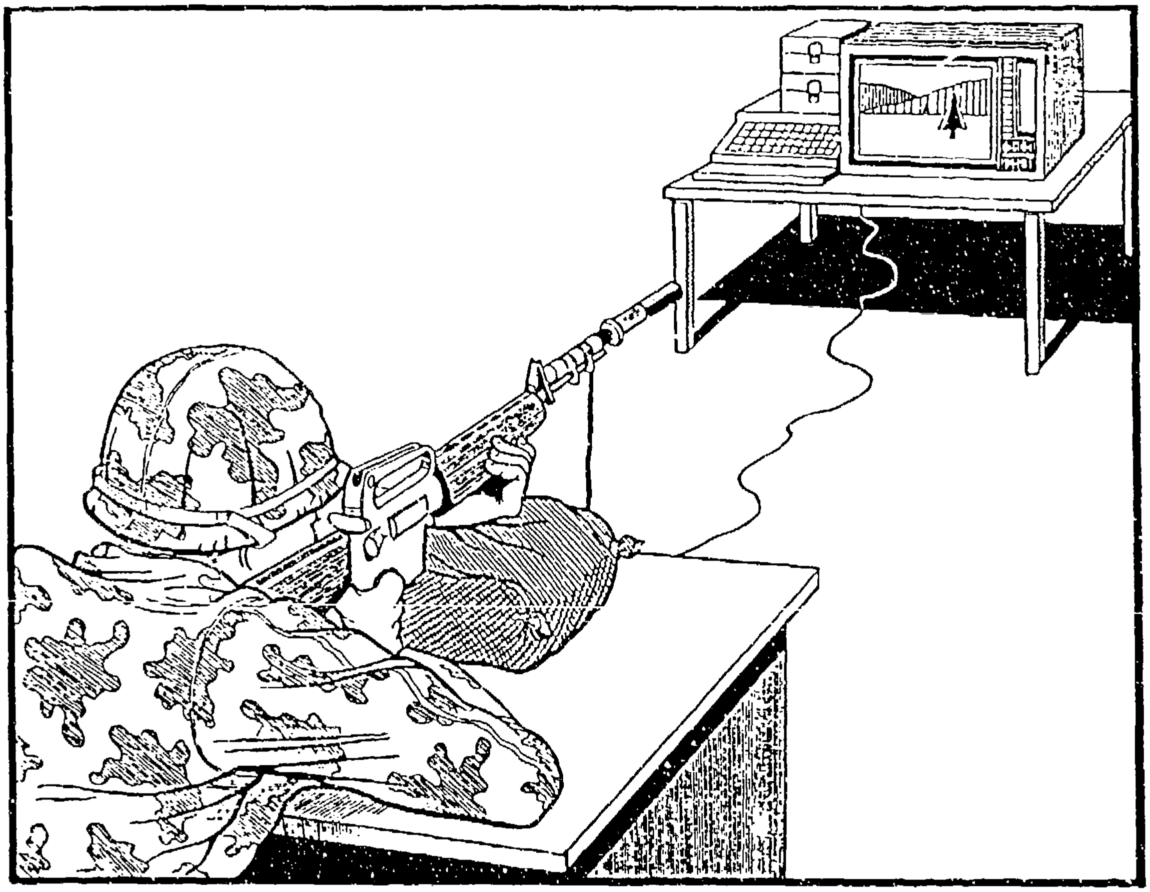

Figure 1. The Multipurpose Arcade Combat Simulator (MACS).

The software was cartridge-based and included three training subprograms; practice record fire, point of aim, and diagnostics. During practice record fire, soldiers fired forty shots at silhouette targets of prone (F-type) and kneeling (E-type) soldiers. Targets were scaled, in terms of visual angle, to represent 50, 100, 150, 200, 250 and 300 m firing ranges. The target course consisted of twenty-nine different screens. Eighteen of the screens had single targets and eleven of the screens had two targets for a total of forty targets. The first sixteen screens were fired from a prone-supported position and the last thirteen screens were fired prone-unsupported. Targets remained in view for a limited amount of time for each screen or until hit. The amount of time allowed for any particular screen was the same for all subjects and was preset in the program. Screen times ranged from 3.5 to 12.5 seconds and corresponded roughly with difficulty in terms of size and number of targets on the screen. Location of each "bullet" strike was shown immediately after each shot in the form of a small cross hair on the screen. After firing the

entire target course, the computer provided each soldier with his or her number of hits, misses, misfires, and an overall accuracy score. The accuracy score was based on the average miss distance of shots from the correct target aim point.

The point-of-aim program was untimed and designed to train soldiers how to identify and shoot at the correct aim point for prone and kneeling target silhouettes. This program consisted of six targets presented one at a time and scaled, in terms of visual angle, to represent 50, 100, 150, 200, 250, and 300 meter firing ranges. After each shot, location of bullet strike was shown by means of a small cross hair. In addition, the computer monitor displayed each soldier's point of aim movements for the last 6.5 seconds prior to each shot (or for whatever amount of time was spent aiming if less than 6.5 seconds). Because individual shot scores were not automatically recorded by the current software, performance on the point of aim program was not evaluated.

The diagnostic program was also untimed and consisted of eighteen 250 m targets presented one at a time. The first nine shots were fired prone-supported and the last nine were fired prone-unsupported. After each shot the computer, by means of a small cross hair, displayed the bullet strike location and each soldiers' point of aim movements for the last 12.8 seconds before the shot (or for whatever amount of time was spent aiming if less than 12.8 seconds). Also displayed after each shot were scores for steadiness (point of aim for .5 seconds before trigger squeeze), trigger squeeze (steadiness during trigger squeeze), follow through (steadiness for .5 seconds after trigger squeeze) and a shot location, (aiming score), based on miss distance from the correct point of aim. After eighteen shots, the computer displayed average scores for steadiness, trigger squeeze, follow through and aiming. Detailed information about both hardware and software can be found elsewhere (Schroeder, 1984).

Design

Individual soldiers were assigned randomly to one of five groups (one control and four experimental) under the constraint that each group contain roughly the same proportion of soldiers with different shooting abilities (i.e., high = 24-36 hits, medium = 15-23 hits, and low = 0 to 14 hits--dividing the distribution roughly into thirds) as determined during pre-record fire on the range. Following pre-record fire, separate groups received different amounts and schedules of MACS training. Table 1 shows the treatment conditions along with the number of soldiers assigned to each on the basis of shooting ability. The Control Group received no training on the MACS, but shot both pre-and postrecord fire on the range. The Familiarization Group received 1 session of MACS training one month prior to shooting postrecord fire. This MACS session consisted of practice record fire, point of aim, diagnostics, and practice record fire again, in that order. The Massed Group received three successive sessions of MACS training with a five-minute intervening break. The Spaced-short Group received three sessions of MACS training with a 2-hr break period inserted between successive sessions. The Spaced-long Group also received three MACS training sessions, but spaced at one-month intervals. The interval between pre- and postrecord fire was 4 months for all groups while the interval between the last MACS training session and postrecord fire was 1

Table 1

Treatment Design

Group	Ability Level	(N)	Pretest	1 Mo. after Pretest	2 Mos. after Pretest	3 Mos. after Pretest	4 Mos. after Pretest
Control	Low Medium High	(7) (9) (8)	Pre-record fire	---	---	---	Postrecord fire
Familiar-ization	Low Medium High	(5) (7) (6)	Pre-record fire	---	---	1 MACS session	Postrecord fire
Massed Practice	Low Medium High	(6) (5) (7)	Pre-record fire	---	---	3 MACS sessions, 5 min. break between	Postrecord fire
Spaced Short	Low Medium High	(6) (10) (6)	Pre-record fire	---	---	3 MACS sessions, 2 hr. break between	Postrecord fire
Spaced Long	Low Medium High	(4) (10) (5)	Pre-record fire	1 MACS session	1 MACS session	1 MACS session	Postrecord fire

month for each of the four experimental groups. After the final MACS training session, soldiers completed a questionnaire designed to reveal their opinions about MACS effectiveness and solicit comments about how MACS could be improved and whether or not they would use the MACS if it were available.

Procedure

Pre- and postrecord fire. Soldiers shot pre- and postrecord fire with one of six new M16A1 rifles fitted with .22 caliber rimfire adapters. Each rifle was zeroed once by an ARNG expert marksman prior to pre-record firing. Each soldier then fired both pre-and postrecord fire with the same rifle to reduce effects of weapon variability. All live firing was done on a single indoor range using target course "C" 25 m/1000 in, reduced for 50 ft firing. Both pre- and postrecord firing was conducted by military range personnel and monitored by the project contractor.

After prefiring, soldiers were placed in either a high, medium, or low ability category on the basis of the number of hits out of thirty-six shots fired. Roughly the same proportion of soldiers from each category were then assigned randomly to each treatment group.

Pre- and postrecord fire performance measures. During both pre- and postrecord fire, soldiers shot at three target sheets. Each target sheet contained seven individual targets scaled to simulate firing ranges from 100m to 400m. Performance on only six of the seven targets on each sheet was scored. One target, the 400m target in the upper right-hand corner of the target sheet, was disregarded because it was much closer to the edge of the target sheet than the other targets and as a result a high number of shots aimed at that target missed the sheet.

One of the three target sheets was scored for slow firing from the prone-supported position. Slow fire allowed four minutes to fire four shots (one shot at each of four targets). Although four shots were fired at the first sheet, only three shots were scored, since the 400m target had been disregarded as noted above, and was not scored. A second target sheet was scored for slow firing from five different positions (i.e., mixed positions, including prone-unsupported, sitting, squatting, kneeling and standing). In this case fifteen shots were scored. A third sheet was scored for rapid fire from two positions (i.e., standing to prone unsupported and standing to sitting). Rapid fire allowed sixty seconds to fire nine rounds (three at each of three targets) in each position. In this case eighteen shots were scored.

The pre- and postrecord fire targets were scored for hits, miss distance, shot group variability and shot group displacement (see Table 2) using the shot-group analysis program prepared by Thomas and Schroeder (1985). Because this program requires an accounting of all shots fired, it was modified to accommodate missing shots. Missing shots were assigned a miss distance equal to that of the worst shot by that soldier at that target, or the distance to the edge of the target sheet, whichever was greater.

Table 2

Pre- and Postrecord Fire Performance Measures

Shot Group	No. of Shots	Shooting Positions	Dependent Measures
Prone-supported	3	All prone-supported	One shot at each of 3 targets for which the following were computed: 1. *Hits;* the number of bullets that land within the target area. 2. *Miss distance;* the median, in millimeters (mm), of the distances by which the shots missed the center (aim point) of the target. 3. *Shot group variability;* the median, in mm, of the distance that the shots were displaced from the shot-group center (i.e., the mean XY coordinate for the shot group). 4. *Shot group displacement;* the distance in mm from shot-group center to the center (aim point) of the target.
Mixed positions	15	5 positions; prone-supported, sitting squatting, kneeling, and standing	One shot in each position at each of 3 targets. The same four scores were computed as described for prone-supported.
Rapid fire	18	2 positions; standing to prone, and standing to sitting. Sixty seconds allowed for each position	Three shots in each position at each of 3 targets. The same four scores were computed as described for prone supported.
Combined	36	Combines all shots described above into one 36-shot group	The same four scores were computed as described for prone supported

MACS training. At each MACS training session soldiers fired at stationary targets presented on the computer monitor. Each training session lasted about 45 min and included the three subprograms described earlier with two repetitions of practice record fire (i.e., practice record re, point of aim, diagnostics, and practice record fire). Soldiers trained on one of six available MACS systems set up on the floor of the indoor range used for pre- and postrecord firing. All MACS training sessions were conducted by the project contractor.

MACS dependent measures. The following measures of soldier performance on MACS were recorded:

(a) For practice record fire, hits were recorded and miss distances for each shot were computed. The MACS scoring program was modified to determine median miss distance for prone-supported shots, prone unsupported shots and all prone shots combined. These miss distances were expressed in pixel (picture element) widths to take into account the difference in pixel height and pixel width. The ratio of pixel height to width was 1.3:1.

(b) For the diagnostic program, means were computed for measures of steadiness taken for .5 seconds before trigger squeeze, during trigger squeeze, and for .5 seconds after trigger squeeze. As in practice record fire, median miss distance was computed for prone-supported shots, prone-unsupported shots and all prone shots combined.

RESULTS

Pre- and Postrecord Fire Performance

Separate 5 (group) x 3 (ability level), between-Ss, unequal n, analyses of variance (ANOVAs) were performed on pre- and postrecord fire mean difference scores[1] for hits and median[2] difference scores for miss distance (MD), shot group variability (SGV), and shot group displacement (SGD) for each firing position identified earlier, i.e., prone-supported, mixed, rapid fire, and combined. The mean and median difference scores (i.e., postrecord fire minus pre-record fire) associated with these analyses are shown in Table 3. The rejection region for all analyses was .05.

The results were consistent. Contrary to expectation, performance of the control group did not decrease over the four-month period of no practice between pre-and postrecord firing. In addition, none of the experimental groups performed better than the control group on any of the dependent measures for any of the firing positions. Thus, the groups that

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[1]Potential concerns over use of difference scores were met by performing analyses of covariance recommended by Hendrix, Carter, and Hintze (1979) which adjust for possible distortions when difference scores are used. These analyses, performed with and without the "Ability" factor, revealed results similar to those of the two-factor ANOVA.

[2]Parallel analyses of means produced fewer significant differences than those performed on the medians.

Table 3

Pre- and Postrecord Fire Difference Scores[1]

		Firing Position															
	Ability	Prone				Mixed				Rapid Fire				Combined			
Group	Level	H[2]	MD	SGV	SGD	H	MD	SGV	SGD	H	MD	SGV	SGD	H	MD	SGV	SGD
Control	Low	0.9	-13.0	-10.9	-13.3	4.7	-13.9	-3.1	-17.0	5.4	-8.4	-3.7	-12.4	11.0	-12.2	-2.7	-15.3
	Med	0.1	3.1	2.2	5.0	0.3	-1.9	-0.4	-3.3	-0.4	1.8	0.6	1.4	0.0	1.9	0.7	-0.9
	High	-0.1	5.8	2.0	2.1	-0.4	-2.4	1.0	0.3	0.0	0.0	-1.3	2.1	-0.5	0.3	-1.3	0.3
Familiar-ization	Low	0.6	-18.4	-2.4	-12.8	2.2	-14.6	-1.8	-14.8	3.8	-11.8	-2.0	-12.2	6.6	-11.0	-6.0	-10.6
	Med	0.6	-13.9	-2.1	-12.1	2.0	5.6	-2.6	-9.9	1.3	0.1	-2.6	0.7	3.9	-2.9	-3.1	-5.4
	High	-0.2	-0.3	-0.3	-0.5	-0.5	0.7	2.5	-1.7	-1.0	4.5	1.3	6.6	-1.7	3.0	0.5	1.0
Massed	Low	0.0	-5.7	-10.5	-8.7	2.2	-14.3	-2.0	-15.2	2.5	-0.5	2.2	-4.0	4.7	-6.8	-0.3	-8.2
	Med	1.0	-3.4	4.6	-5.0	0.2	4.2	5.6	4.2	-1.8	5.4	-4.0	4.8	-0.6	4.4	0.4	4.0
	High	-0.3	7.5	-0.4	8.7	-0.1	4.0	-3.7	2.4	-3.1	2.6	1.6	0.6	-3.6	2.4	0.7	2.0
Spaced Short	Low	0.8	-4.3	0.3	-8.0	2.5	-2.2	-3.3	-2.5	4.2	-18.2	-14.8	-19.7	7.5	-7.2	-8.6	-10.7
	Med	0.1	3.8	-0.4	-0.3	0.1	1.1	-2.2	1.3	3.2	-1.8	-4.4	-0.6	3.4	-0.1	-2.6	1.1
	High	1.0	-9.5	-3.2	-10.5	0.8	-4.8	1.5	-5.7	-1.0	-2.0	0.2	1.0	0.8	-4.5	-0.3	-3.0
Spaced Long	Low	1.3	-12.3	-32.0	-6.5	2.5	-22.0	-12.7	-25.8	2.8	-8.3	-11.3	3.8	6.5	-12.0	-19.5	-0.8
	Med	0.5	1.0	-1.1	-3.0	2.2	-5.5	-0.3	-7.0	3.1	-4.9	-2.7	-6.0	5.8	-5.4	-1.6	-7.1
	High	0.2	1.0	4.0	0.0	-2.2	2.8	4.0	-3.0	0.2	-2.6	1.2	-3.8	-2.2	1.4	3.2	-4.6

[1] Difference scores were computed by subtracting the pre-record fire score from the postrecord fire score. Differences for hits are expressed as the mean of pre/post differences; differences for MD, SGV, and SGD are expressed as the mean of pre/post differences in medians.

[2] H = Hits; MD = Miss Distance; SGV = Shot Group Variability; SGD = Shot Group Displacement.

practiced with MACS performed no better than the group that did not. Because of these unexpected findings, no conclusion about how much or when to conduct MACS training can be made other than to say that it made no difference within the context of this experiment.

There was, however, a significant main effect of ability level with $F(2,86) = 16.01$ for overall hits, 18.22 for overall miss distance, 10.70 for overall shot group variability, and 7.03 for shot group displacement. Shooters of low pretest ability showed more improvement on the postrecord fire than those with higher incoming ability. This was true for all groups (including the control group) and for all four indicators of marksmanship skill. Ability level, however, did not interact with training group. Thus, only lower ability shooters benefited from any sort of practice, with MACS or with real weapons (i.e., pre-record fire).

Within-MACS Analyses

To determine if MACS performance was influenced by amount of MACS practice, separate 3 (Sessions: 1, 2, and 3) x 3 (groups: Massed, Spaced-short, and Spaced-long) mixed ANOVAs were performed on the four performance measures from the diagnostics subprogram of each MACS session (i.e., steadiness, trigger squeeze, follow through, and miss distance) and the two performance measures from the last practice record fire segment of each MACS session (i.e., hits and miss distance). No significant main or interaction effects were found. Thus, no aspect of MACS performance improved as a function of the amount or schedule of additional practice.

Correlations Between MACS and Record Fire

The lack of performance improvement across cumulative sessions of MACS training made it impractical to perform tests of association between improvement in MACS performance and improvement in live record fire performance. However, correlational analyses were performed to determine whether any MACS performance measures were predictive of postrecord fire, and if so, which ones. Correlations were calculated for soldiers in the massed, spaced-short and spaced-long groups between all postrecord fire measures and all within-MACS measures. Only those found for the combined positions from postrecord fire and the measures for diagnostics and final practice record fire of the third MACS training session are reported in Table 4. Coefficients for the correlations not reported were similar, but generally lower in magnitude than those shown in the table.

Many of the correlations between MACS and postrecord fire variables were statistically significant. However, they were generally of low magnitude. The best MACS predictor of all postrecord fire dependent measures was the number of hits from the final practice record fire of the last MACS session with the next best predictor being miss distance on the final practice record fire. Correlations for diagnostic variables (i.e., steadiness, trigger squeeze, and follow through) were modest compared to those for practice record fire.

Questionnaire Data

Analysis of the questionnaire data summarized in Table 5 revealed that

Table 4

Correlation of Postrecord Fire Measures for the Combined Shot Group with Measures from the Practice Record Fire and Diagnostics Training Subprogram from the Final MACS Session

	Postrecord Fire Dependent Measures			
MACS Variable	Hits	Miss Distance	Shot Group Variability	Shot Group Displacemt
Diagnostics:				
Steadiness	.24	-.16*	-.27	.00*
Trigger Squeeze	.35	-.28	-.26	-.25
Follow Through	.38	-.31	-.27	-.25
Supported Miss Distance	-.22	.21	.46	.08*
Unsupported Miss Distance	-.17	.19*	.36	.04*
Total Miss Distance	-.25	.28	.51	.08*
Final Practice Record Fire:				
Hits	.45	-.49	-.53	-.39
Total Miss Distance	-.38	.38	.41	.24

n=58
*Not statistically significant (p >.05)

Table 5

MACS Questionnaire

1. Do you think that training on MACS will improve your marksmanship performance with the M16A1 rifle? Yes 93%* No 7%

   If yes, what marksmanship skills should be improved?

Trigger Squeeze:	29.3%
Steadiness:	28.7%
Point of Aim:	16.3%
Breath Control:	8.0%
Follow-through:	8.0%

2. Rate the following feedback information provided by MACS during the DIAGNOSTIC training program on how useful you think it was in helping you improve your marksmanship skill.

	Of No Use	Not Very Useful	Of Use	Of Great Use	Extremely Useful
Shot Location	.9%	.2%	13.3%	19.5%	16.3%
Steadiness	.6%	1.1%	10.7%	28.8%	8.5%
Trigger Squeeze	1.1%	6.6%	6.4%	30.1%	11.9%
Follow Through	1.1%	5.0%	16.6%	14.5%	13.1%

3. Do you think that MACS should be improved in any way to enhance its training effectiveness? Yes 51.7% No 48.3%

   If yes, what changes would you recommend?

   21.0% Add Recoil
   8.3% Better Target Background
   16.3% Change Weight (Light pen at end of barrel is too heavy)

4. Did you enjoy training on the MACS? Yes 98.1% No 1.9%

5. Would you practice with MACS if it were located in your local armory? Yes 96.1% No 3.9%

*Percentages for some items do not add to 100% because not all soldiers chose to answer every item..

93% of the soldiers in the experimental groups thought that MACS training would improve their marksmanship performance and 98.1% enjoyed the training. Most also rated the various forms of feedback provided by the MACS diagnostic program to be useful in improving different aspects of their marksmanship skill and thought that some device improvements could be made to increase its training effectiveness. The three changes suggested most were to add recoil (21%), change the weight distribution of the weapon (16.3%), i.e., use a lighter light pen, and enhance the target background (8.3%). Lastly, an overwhelming majority (96.1%) of soldiers said that they would practice on the MACS if it were available in their local armory.

DISCUSSION

The results of this research can be interpreted to suggest that MACS training does not promote sustainment of rifle marksmanship skills and that MACS performance does not predict live-fire performance very well. These conclusions, however, must remain only tentative because in most cases the null hypothesis was not rejected. Factors other than the ineffectiveness of MACS must be considered as potential contributors to the lack of statistically significant findings (Boldovici, in press).

First of all, no decay (i.e., forgetting) of marksmanship skill was observed for the control group over the four-month, no-practice interval between pre- and postrecord firing. Because such decay is a prerequisite for examining sustainment, it is clear that what was being examined was the learning of additional marksmanship skills and not sustainment of those learned previously. It is possible that marksmanship skills do not degrade or that the no-practice interval was too short for forgetting to occur. In either case, sustainment could not be examined.

Second, inherent variability of the rimfire-adapted weapons used for pre- and postrecord firing may have decreased the chances of finding significant MACS training effects (Unit Rifle Marksmanship Training Guide, 1984). This was possible even though steps were taken to reduce variability associated with use of the weapons (i.e., one person zeroed all rifles and soldiers used the same rifle for both pre- and postrecord firing).

Third, the relatively small number of soldiers used in the research may have decreased statistical power to a degree where significant differences were hard to find. Everything else being equal, the probability that numerical differences will be statistically significant declines with decreasing numbers of soldiers (Boldovici, in press). Although this argument generally holds merit, most of the F-ratios obtained in this experiment were not close to being significant, and thus, use of small sample sizes may have been a contributing factor but probably not the main reason for the lack of significant effects.

Fourth, MACS training may have not been effective simply because of the way it was conducted. For example, soldiers completed the MACS training subprograms without the benefit of any coaching from a marksmanship instructor. This was by design, however, in that we were interested in knowing how well the MACS could train on its own. While the MACS does provide valuable feedback about shooting performance such as

steadiness, trigger squeeze, and shot location, it does not tell shooters how to modify their technique, and therefore, rectify any identified deficiencies. Thus, for MACS training to be effective one could speculate that an instructor must be present to provide this information. An alternative approach would involve modifying MACS software to fill this instructor gap.

Fifth, the amount of MACS training may have been insufficient to promote any performance improvement across sessions. Thus, even the groups that received three sessions with MACS may not have had enough training to make a difference.

Sixth, whatever was learned from MACS training could have been forgotten over the 1-month no-practice interval, common to all experimental groups, scheduled just prior to postrecord fire. For this notion to hold merit, one would have to argue that rifle marksmanship skills decay relatively rapidly or that skills learned under MACS training are more transitory than those learned under real weapons training. While the former argument is contrary to the findings of the present experiment, and the validity of the latter has yet to be examined, it is possible that MACS training benefits may have been greater had the interval between the last MACS practice session and postrecord firing been shorter.

Lastly, the finding that most soldiers who trained on the MACS perceived it as helpful and enjoyable suggests that implementation efforts would meet little resistance from trainees themselves should MACS prove effective in future research. Further research is necessary to determine the validity of the issues just discussed. This research should examine sustainment of marksmanship skills over no-practice intervals longer than four months between pre- and postrecord firing and shorter than one month between the last MACS practice session and postrecord firing, reduce inherent weapon variability by using M16A1 rifles without the rimfire adapters (outdoor range required), employ larger sample sizes with a greater number of MACS training sessions, and explore the need for an instructor to be present during these sessions.

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